Grounding Oriented Design

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Certificate of Authorship and Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student

Acknowledgements

A huge "thankyou" goes to my supervisor, Professor Mary-Anne Williams. In late 2001, I was a disillusioned software engineer, bored with my chosen career path, drifting from one job to the next, searching for something more, and for some strange reason, I found myself spending my time at work daydreaming about artificial intelligence (perhaps because I wanted the machines I was programming to do the work for me). So, I made inquiries at my local university (Newcastle) about the possibility of undertaking a research honours degree in artificial intelligence. These inquiries led me to Mary-Anne, and as the cliche goes, the rest is history. Mary-Anne introduced me to robotic soccer, offered me the opportunity to undertake a PhD at UTS, entrusted with me an important leadership role (leading the software development for the UTS RoboCup team), allowed me the freedom to pursue the research areas that interested me, provided me with the opportunity to discuss the grounding problem with great minds such as John McCarthy and Peter Gärdenfors, and gave me the guidance to keep me pointed in the right direction. Not only was her guidance and support invaluable, but she has been a great mentor.

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Abstract

The symbol grounding problem[67] is a longstanding, poorly understood issue that has interested philosophers, computer scientists, and cognitive scientists alike. The grounding problem, in its various guises, refers to the task of creating *meaningful* representations for artificial agents. After more than 15 years of widespread debate and circular introspection of the so-called symbol grounding problem we seem none-the-wiser as to what constitutes being meaningful, and indeed grounded, for an agent[128].

We argue, in the context of practical robotics, a grounded agent possesses a representation which faithfully reflects pertinent aspects of the world. In contrast, an ungrounded agent could be, for example, delusional or suffering from hallucinations ("false positives"), overly concerned with irrelevant things (e.g. the frame problem[93]), or incapable of reliably perceiving, recognising or anticipating relevant things in a timely manner ("false negatives"). While most grounding research concerns how to develop agents which can autonomously develop their own representations (i.e. *autonomous* grounding), the fact all robotic systems are grounded through human design on a case-by-case, ad-hoc basis has been overlooked. This thesis presents *Grounding Oriented Design* - a methodology for designing and grounding the "minds" of robotic agents. Grounding Oriented Design (or, alternatively *Go-Design*) is a vital first step towards the development of autonomous grounding capabilities through improved understanding of the processes by which human designers ground robot minds.

Grounding Oriented Design offers guidelines and processes for iteratively decomposing a robot control problem into a set of collaborating skills, together with a notation for representing and documenting skill designs. Grounding Oriented Design consists of two main phases: basic-design which involves constructing a skill-architecture, and a detailed-design in which a skill-architecture is used to design the agent's representation and decision-making processes. A groundedness framework[143] is used for describing and assessing the groundedness of either the complete system or of individual skills. Examples of the methodology's use and benefits are provided, while suggestions for future work are discussed.